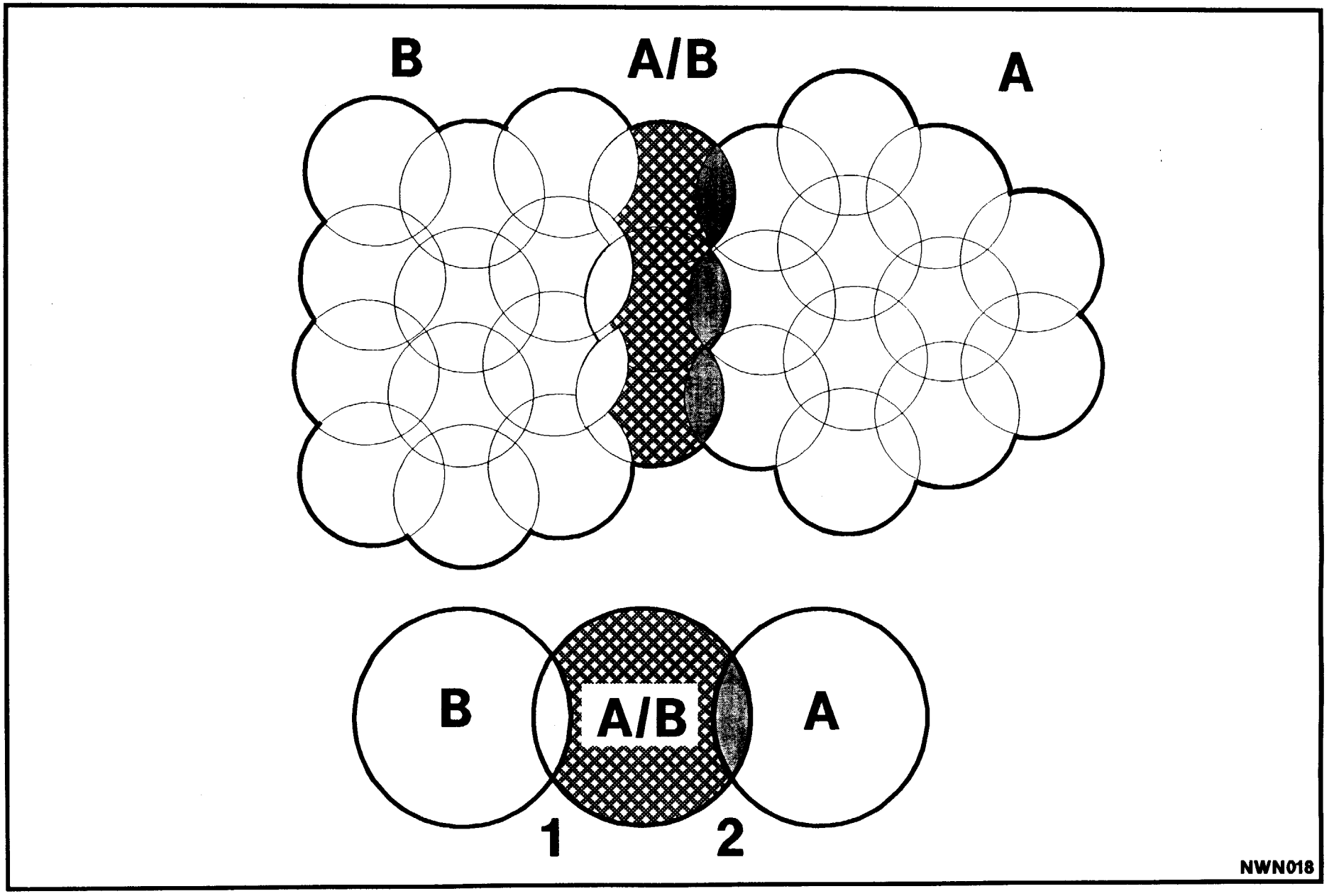
Mtel

Figure 8: NWN Dynamic Zone Allocation



provide service to terminals at the boundary between two zones. Such a technique may be employed if the traffic levels on the system dictate.[6]

In a static zone allocation, the set of transmitters denoted in Figure 8 by A/B can be joined either to Zone A or Zone B. In each case, there would be an overlapping area between two zones (shaded area in Figure 8) where signals from the two zones would interfere, reduce probability of reception and increase probability of false calls. (Note that, unlike multi-frequency systems, the same carrier frequency is used in adjacent zones.)

This problem can be resolved in a static zone network by sending messages to portable stations located in overlapping areas only during the nationwide simulcast cycle (during which time Zone A and Zone B are merged and there is no interference).

Mtel proposes a novel technique that would provide simulcast quality service in overlapping areas, without resorting to nationwide message broadcast. This would reduce the percentage of time when a single message is broadcast nationwide, instead of multiple simultaneous messages (one per zone), and would increase the overall network capacity. The basic prerequisite is the possibility that transmitters can switch from one zone to another between cycles, which Mtel calls Dynamic Zone Allocation (DZA).

In Figure 8 the transmitters denoted by A/B would alternately broadcast messages in simulcast with Zone A (in even cycles) and Zone B (in odd cycles). During even cycles no messages would be directed to portable stations in shaded region 1 of the blown-up picture, while regions A, A/B and shaded region 2 would be covered by Zone A traffic. Simultaneously region B would be covered by different Zone B traffic. Alternately, during odd cycles, regions B, A/B, and overlap 1 will have the same traffic; Zone A will have a different signal and no messages will be scheduled for portable stations located in overlap 2, where interference is expected.

In other words, when the NWN knows that a portable station is in an overlap area, where interference is high, the NOC would not attempt transmission. In the next cycle, the NOC would shift the overlap area and perform reliable message delivery.

The DZA technique will also be used to reduce coverage of zones with high call rate and increase coverage areas in zones with low call rate to equalize traffic in all zones and maximize network capacity with a given number of zones. If the demand outgrows the network capacity, an automatic increase in the number of zones will be triggered followed by zonal boundary adjustments.

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[6] Precise tailoring of the coverage area through use of highly directional antennas with carefully engineered heights and powers is another technique that may be employed to conserve capacity in the nationwide portion of the cycle by minimizing the interference area between zones.

All these techniques allow an increase in network capacity and better frequency utilization at the expense of increased processing power of the network controller. This is facilitated by knowing the location of portable units and by centralized control. All this processing is transparent to the user, who would experience a high quality, simulcast signal anywhere in the coverage area of the NWN.

2.2 The Intelligent Network

The Intelligent Network (IN) concepts have emerged in the telephone industry as the means for rapidly and efficiently evolving the services provided by a communications network. The essence of the IN is the control of relatively unintelligent transmission and switching facilities by a general purpose computer. The inspiration for this architecture has been the 800 number and calling card services: services that rely upon databases in centralized general purpose computers. IN is the means of migrating this inspiration into a wider context. In so doing the axioms that unfolded include:

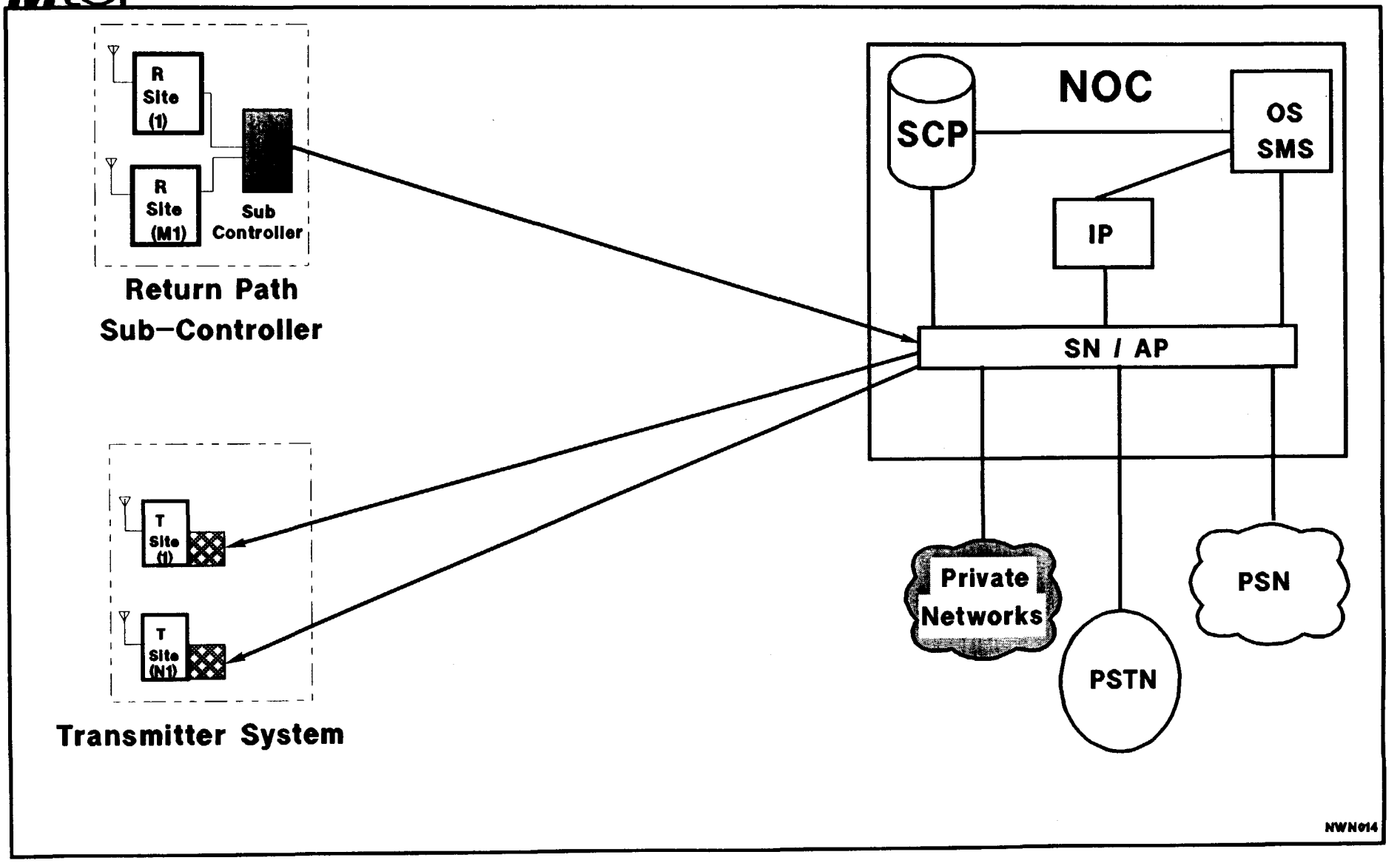
- Establish a framework of software and transmission modules and a structured dialog though which the modules interact;
- Create service scripts that contain the instructions for providing a service;
- Employ service scripts to assemble complex user services; and
- Provide for the migration of functions across physical boundaries.

These axioms, and the structures that support them, have general applicability to a variety of communication systems, including the NWN.

Mtel's NWN IN is illustrated in Figure 9. The functional elements include:

- Service Node (SN)/Access Point (AP) functions that provide the interface of the IN assets to end users (persons or computer processes);
- Intelligent Peripherals (IP) that implement special service activities;
- Service Control Point (SCP) for the tactical (real time) execution of the orders and service scripts from the SMS; and
- Service Management System (SMS) to provide the executive functions for the network: script service orders, collect performance and usage statistics, and maintain user profiles.

Figure 9: NWN IN Architecture



In accordance with the fundamental axioms, these functional entities may be mapped onto one or more physical entities. The types and locations of physical entities are based on cost, performance, load, and administrative trade offs. In the NWN all of the functional entities will be co-resident in the Network Operation Center (NOC) and the NOC will be composed of as many general purpose computers as are necessary to handle the workload. Details of each of the functional elements for this architecture are described below.

2.2.1 Access Point (AP)/Service Node (SN)

This functional block performs the service logic required to process a NWN request (outbound and inbound). The SN/AP is the interface point to the other networks and regional sub-controllers. Therefore, it may be considered as a switching center or a gateway office, with satellite links for the outbound transmission media, communication links to the sub-controllers as the inbound transmission links, and communication links to other networks and service providers. Some of the functions that may be included in this functional block are:

- Interfacing with other networks or service providers. The NWN will provide a seven layer open interface to other networks for sending/receiving a message/request and for future service integration with other service providers.
- Interfacing with the Return Path Sub-controllers (RPSCs).
- Interfacing with the NWN SCP for access to customer service profile.
- Interconnecting with the intelligent peripheral to engage information interactions with the users.
- Translating and message routing.
- Setting up and tearing down calls.
- Interfacing with SMS/OS for customer validation and authorization requests.

2.2.2 Intelligent Peripheral (IP)

The IP provides resources such as voice announcements, voice recognition, DTMF digit collection and contains the service logic to connect the users to these resources. The IP provides such services as customized announcements for closed user groups, special announcements depending on time of day, and other functions.

Currently, NWN has one centralized IP; however, as the need for user interaction increases, more IPs will be deployed in the network to address customer's special needs.

2.2.3 Service Control Point (SCP)

The SCP contains the logic required to process NWN calls and/or requests. The types of tasks the SCP provides may be divided into two categories:

- Call/message processing request. This request is initiated by the SN/AP. The SCP receives a request from the service node, accesses a service script based on information contained in the request (e.g., outbound, authorization request) and performs the logic required to process the service. The SCP may then instruct the Service Node (SN) for further processing of the request. For example, instructions may include providing for customer interaction by interconnecting an Intelligent Peripheral (IP).

- Service management/operation processing request. This request is initiated by the SMS or OS in order to update, add or delete a customer service profile or initiate a new software load.

2.2.4 Service Management System (SMS) and Operations Systems (OS)

This functional block provides intelligent management for the NWN. It has two subsystems:

- Service Management System. This functional block performs the service management and customer related information functions such as:

  -- Service billing and message accounting
  -- Call priority management
  -- Security management
  -- Usage monitoring among terminals
  -- Adaptive registration based on the customer traffic pattern and location
  -- Customer authorization and authentication procedures
  -- Updating customer service profile in the SCP

- Operations System. This functional block performs the Operations, Administration and Maintenance (OA&M) functions for the NWN, such as:

  -- Performance monitoring
  -- Diagnostics
  -- Network reconfiguration
  -- Scheduled maintenance
  -- Operator services
  -- Help desk

3 System Interfaces

The NOC, insuring the required taut control, provides an open interface to outside systems and services using industry standard communication techniques. In consonance with the IN principle, these interfaces are encoded as AP/SN modules. The NOC provides access to other systems such as the SkyTel™ system, the AMSC system, and other service providers, as well as micro, mini and mainframe based systems (including their associated systems). There are a number of special purpose and general interfaces as described in this section for the NOC to integrate NWN service with end user applications. Most of these special purpose functions are encoded as IP modules.

3.1 NOC to E-mail Gateways Interface

The e-mail industry has adopted and deployed X.400 standard with most of the popular e-mail services and products. X.500 based directory services are also evolving fast.

To provide enabling applications for the next generation of two-way wireless communication systems, such as NWN, it is extremely desirable that they communicate effectively with X.400/X.500 based systems. Mtel will support interface with public and private e-mail services on the advanced messaging system. The NOC will have the capability to communicate with external e-mail services using X.400/X.500 standard interface.

Given Mtel's expertise in providing e-mail gateway with a universal messaging system in the SkyTel™ system, we will be able to offer an X.400 gateway with the first service offering of NWN.

A user of external e-mail service will be able to address a message to an NWN subscriber by simply identifying the NWN address. The NOC will receive this message through the NWN e-mail gateway and send the message to the NWN subscriber over the NWN network. A subscriber of NWN services can originate a message reply from the portable unit and the NOC will route that message, if so addressed, to an e-mail system via the e-mail gateway.

3.2 NOC to Computers Interface

The NOC supports different access methods depending on user application needs. These interfaces will allow system solution providers to integrate NWN based services with their existing applications. Following is a list of such interfaces:

- X.25 based PSN access.
- Dial-up modem access.
- Dedicated leased lines access.

The NOC will support ISO-OSI standards as specified in the protocol section of this document to facilitate communication with outside systems. Although, the first service offering will be limited to supporting specific message structures as defined in the protocol section of this document, later service offerings will support full OSI standards.

3.3 NOC to End User Interface

The end user also will be able to communicate with the NOC using a public telephone interface. The NOC will use state of the art voice technologies to facilitate this interface. The following voice technologies will be used:

- Digitized voice: Speech "prompts" will be digitized, recorded and played back to the user.

- Text to speech: ASCII text messages will be converted into intelligible speech using such features as number parsing, voice selection and speaking rate selection.

- Automatic speech recognition: Speaker independent recognition, as this technology develops, will be used over the telephone to accept user data and commands.

The user will be presented with a simple menu of choices and either keypad or voice input will be available to accept user data and commands. The NOC will support a personal computer interface with desktop, laptop and palmtop devices using Mtel provided software to allow end users to communicate with the NOC over public networks.

Another NWN interface will accept Group III faxes and use proprietary character recognition technology to read a fax page and convert fax data into ASCII text. Users will submit their messages using fax and the fax gateway will translate that data for the NOC to deliver to NWN subscribers as text information.

3.4 Interconnection to Other Networks

The interconnection to the other networks such as PSTN, PSN and other private networks are performed via the NOC.

Signalling System 7 (SS7) is a signalling method in which a single channel conveys, by means of labelled messages, signalling information relating to a large number of circuits and provides the capability to introduce a variety of new services. Although SS7 was designed to support the requirements of telephony, it has and continues to be, enhanced for other purposes such as access to the network databases. The Transaction Capability Application Part (TCAP) is the application level protocol of SS7 transaction capabilities which defines a set of protocols and functions for the transfer of information between distributed applications

in a network, such as between a Service Node (SN) and a database. TCAP provides the procedures for an application at one node to request another node to perform and return the results of an operation. The Application Service Element (ASE) provides the specific information (e.g., Personal Identification Number) that should be exchanged between two nodes for processing the request.

The NWN may use SS7 TCAP for access to its SCP. By supporting the SS7 protocol the NWN will allow open interface for interconnection with other databases and application layers.

4 Transmission

NWN's transmission facilities are arranged in a ring of five nodes, with each node linked to its successor in the ring by a uni-directional transmission link custom designed at both the physical (bit-transfer) and protocol level for that specific purpose. This section describes those nodes and links.

The five major NWN transmission nodes are:

- The transmission portions of the Network Operations Center (NOC) including the (possibly remote) satellite transmit (up-link) stations.
- The Transmitter Base Stations that receive satellite bit streams (downlink) and relay the traffic over the associated 930 MHz radio links.
- The User (generally portable) Terminals that are actively involved in all NWN transmissions, since the only return path to the NOC for routine traffic (including acknowledgments) is via a User Terminal.
- The Receiver Base Stations that collect the User Terminal transmissions and relay them back toward the NOC;
- The Return Path Sub-Controllers that act as concentrators, collecting traffic from a number of Receiver Base Stations and forward the traffic to the NOC over high speed point-to-point links.

See Figure 10 for an illustration of the outbound path and Figure 11 for an illustration of the inbound path.

4.1 RPSC (Return Path Sub-Controllers)

The Return Path Sub-controller acts as a concentrator/multiplexor for inbound operations. It collects the messages from the NWN subscriber and forwards them to the NOC. All the

Figure 10: NWN Outbound Path

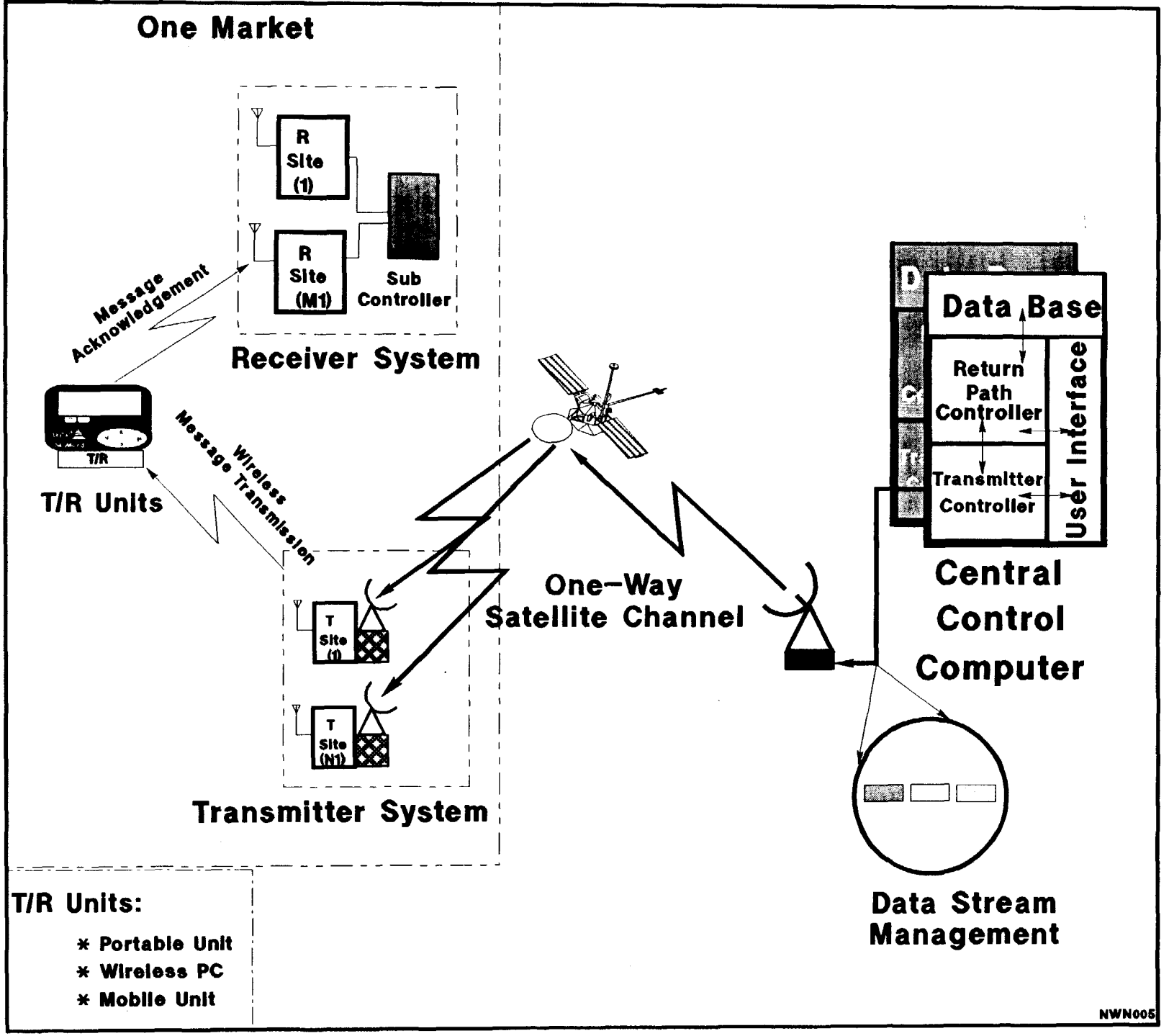
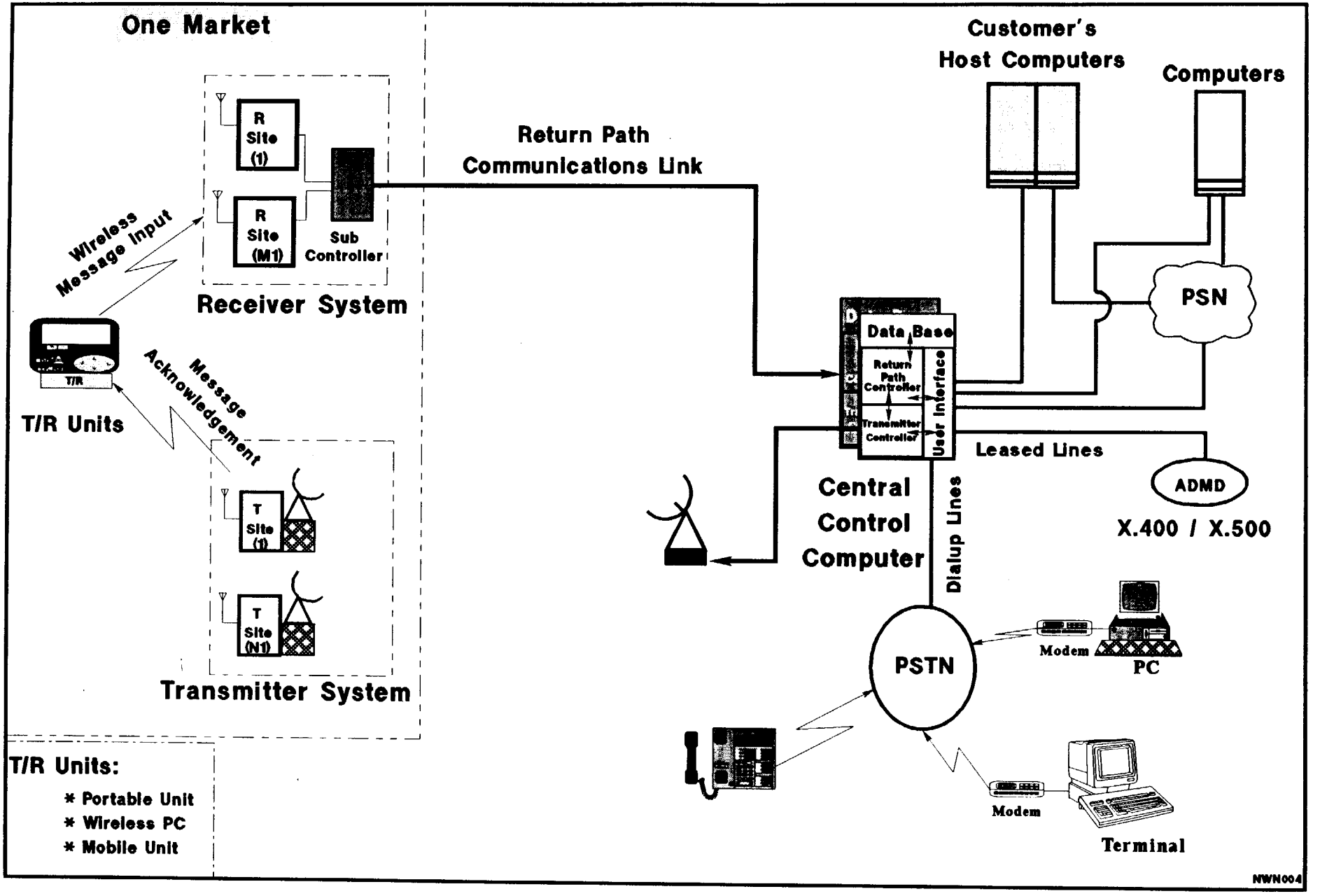


Figure 11: NWN Inbound Path



required service management procedures such as authorization and verification are performed by the NOC. The RPSCs may be viewed as "dumb" access points in the network.

The receivers and associated sub-controller perform the minimal media access and maintenance functions. Our philosophy is to minimize the hardware residing at receiver sites. Since there are so many of them, on-site resident personnel are not economical (although high reliability is maintained because generally two or more receivers are available to most portable terminals).

The receivers contain minimal intelligence, but have an inexpensive local controller for maintenance purposes. Additionally, they can be employed as over-the-air status reporting nodes for the system transmitters and can be used in helping to set transmitter simulcast parameters.

Received packets are forwarded to the sub-controller. The sub-controller is shared by a number of receivers. The primary function of the sub-controllers, aside from alarms and maintenance of the receivers, is to perform media access functions and minimize the data traffic back to the central controller. The specific functions performed by the sub-controllers include :

- Detection of (by CRC error check) messages containing errors and collisions, and keeping track of the number of messages with errors occurring on the registration and message notification contention channel. The central controller is not notified of each error message, but rather only periodic[7] summary counts of collisions are communicated, so as to minimize the traffic. This information may be used by the central controller to adjust the random access parameters (such as retransmission delay) for the purpose of random access stability, as described later.

- A packet from a given portable terminal may be received correctly by two or more receivers. The sub-controller will merge these duplicate packets, maintaining the receiver location identity, to reduce the capacity required on the link to the central controller.

- Portable terminal location information will be used advantageously to allow multiple portable terminals to transmit simultaneously (frequency reuse). Frequency reuse is essential because it minimizes the time allotted in each frame to the reverse channel, thereby increasing the capacity of the forward channel resulting in efficient use of spectrum.

[7] Determined on the basis of threshold.

The sub-controllers will also implement the protocol suite used for communication with the NOC, and communicate merged valid packets to the NOC together with the other media access information.

A random access protocol similar to slotted Aloha will be used on the reverse contention channel in order to allow new portable terminals to initiate a message transmission or registration procedure. This enables portable terminals to access the NWN with a very low delay. Whenever the portable terminal does not receive an acknowledgement, it will assume that a collision occurred and will repeat the transmission with a random delay.

This random access protocol is potentially unstable in high traffic conditions and requires a stabilization technique to avoid a deadlock situation where a large number of collisions are reducing the throughput, further increasing the number of backlogged accesses. This can be alleviated easily, for example, by employing an exponential back-off algorithm.

For exponential back-off, each portable terminal increases its random waiting time by a factor of two each time it transmits unsuccessfully. This technique is used on Ethernet™, and rapidly reduces the collisions when they become unacceptably frequent.

4.2 Links and Protocols

The OSI Reference Model is used as the basis for constructing all of the NWN protocols and standard implementations of these functions will be used wherever possible. OSI provides a 7-layered reference model for network communications.

First Layer: Physical. In the NWN architecture, this layer is represented by the communications links between the central controller and sub-controllers.

Second Layer: Data Link. It provides formatted packet communications between two consecutive nodes in the network. For the NWN application, this layer represents the NOC packet exchange with a sub-controller on one communications link. This layer provides transmission of a group of packets without waiting for individual acknowledgments from the recipient. The maximum number of packets to be sent prior to acknowledgement is set depending on the delays of the communications link. For a low delays line this maximum number of packets is set at 7, while 127 is the maximum number of packets for a two-way satellite channel. The acknowledgement is structured for a group of packets.

Third Layer: Network. The "Network Layer" is necessary for distributed networks where communications between two nodes can be through intermediate nodes in the network (i.e., virtual circuit mechanism). This layer will be deployed to provide continuity of packet transmission in case of primary link failure. This is achieved by automatically establishing a new route as a virtual circuit in a secondary link.

The network layer addresses also allow each node running a process with multiple communication functions to open several virtual circuits with the NOC, each using a unique identifier. In this mode, the node assigns a specific network address for each communications function with the NOC.

Fourth Layer: Transport. The "Transport Layer" provides end-to-end flow control, message partition into frames at the sender end and message assembling at the recipient end. The communications service provides bi-directional transmission for both classes of data: normal (with unlimited size) and express or priority (with limited size). These features will allow the NWN applications to expand to new wireless units using different formats without the need for major modifications to the core of operations of the NWN.

Fifth Layer: Session. The primary function of this layer is to establish sessions between an initiator node and an accepter node for data transfer. Quality of connection is negotiated between the two nodes including timeouts.

Sixth Layer: Presentation. It serves to manipulate different types of data through the network without affecting control characters deployed in packet exchange. It provides translation functions for various types of application data (e.g., fax, E-mail).

Seventh Layer: Application. It is the layer where messages, commands and other information are sent or received at the node in the application environment. In the NWN application, a sub-controller, for example, can use this layer to send inbound wireless messages to the central controller. X.400/X.500 are already in use for many communications applications. Possessing these standard protocols will open NWN's horizons for future services with minimum additional development. Other standard applications layer OSI protocols will be added to the NWN on an as needed basis.

4.2.1 Central Controller to Transmitters and Transmitters to Users

Utilizing digital channel bandwidth on a satellite network, the NOC broadcasts messaging data to NWN transmitters located throughout the country. The protocol consists of one-way communications of formatted packets destined to multiple destinations (i.e., NWN transmitter(s)). The packet format contains several pertinent control fields to provide for message identification, packet sequence numbers within a message, destination identification (i.e., wireless unit) and market/transmitter identification.

Furthermore, this one-way communication enforces error correction at the recipient nodes (i.e., transmitters). Thus, error correcting fields are incorporated in each packet to ensure accurate message transmission from the central controller.

To maintain coherent operations for message transmission from the central controller to transmitters, the central controller establishes a "data stream management" mechanism. This

mechanism oversees and ensures timely batching and optimal message routing in the form of packets to transmitters via the designated satellite channel.

Basically, outbound wireless messages to transmitters will be divided into packets. Each packet will be addressed with the zone ID of the subscriber's location. Packets originated to all NWN zones will be batched together. Using several criteria at the central controller, batches will be sent over the satellite channel.

The data stream management will reflect the order of batching wireless messages as they are scheduled in the central controller. An enhanced scheduler in the central controller coordinates the upcoming transmitter cycles (i.e., on air time slots) and message delivery according to system service and message type.

It is desirable to minimize the functionality at the transmitter sites, since it is easier to administer and maintain hardware at the central controller. The central controller will assemble messages into packets, adding appropriate headers, forward error control redundancy and CRC error detection redundancy. These packets are transmitted over the controller-to-transmitter satellite link and retransmitted to the portable terminals. The transmitter has an on-site controller that has multiple zone information so that the transmitter can be assigned remotely to a zone. The on-site controller processes those packets that are addressed to the assigned zone as well as those to be included in the nationwide portion of the cycle. The on-site controller can also adjust simulcast parameters such as absolute delay and precise frequency adjustments. There is no need for a reverse channel back to the NOC. Rather, the NOC to transmitter and transmitter to portable terminal links are simply concatenated, and error control acknowledgement is handled by the portable terminal.

There are configuration and maintenance functions at the transmitter that require a separate lower-speed two-way channel to the central controller that can be handled economically using a dial-up line with a voiceband data modem. These functions include fault detection and alarms.

4.2.2 End-User Messaging to NWN

The NOC possesses a multitude of interfaces to accept message entry for its wireless subscribers. End-users can input messages using their PCs, laptops, palmtops, mainframes or DTMF telephones. The NOC provides user-friendly and easy mechanisms to perform functions requiring interaction.

For users of PCs, palmtops, laptops or CRT terminals, the NOC provides dial-up interfaces. The NOC will dialogue with the connected device to facilitate the execution of messaging to authorized NWN subscribers. The interfaces will include menu-driven function selections for NWN user access (i.e., message input). In addition, authorized subscribers can perform other functions, such as recalling messages and obtaining coverage information in the protected security mode.

For existing e-mail and X.400/X.500 users, the NOC will provide dedicated and dial-up gateways to serve their messaging needs.

4.2.3 Sub-controllers to NOC Communications

There are two options for the networking infrastructure between Return Path Sub-Controllers and the NOC: (1) dedicated leased lines can be used in a star configuration, or (2) a virtual private network can be created over an existing public packet network. OSI protocols will be used for communications. The primary impact of this link is the delay introduced, which affects the overall protocol design for the NWN, as described later.

Attachment 1 -- NWN Operations

System management and operations involves far more than merely listing and assigning functions. Mtel is applying the lessons it learned in building, managing, and operating the first nationwide paging system to performing these functions for the NWN In this Attachment, Mtel provides additional details concerning how the functions are performed.

A1 Administrative System

Mtel's NWN will include a full business operations support system consisting of hardware and software modules for:

- Billing
- Accounts Receivables
- Collections
- Inventory Tracking
- Configuration Management and Order Entry
- Fraud Prevention and Detection

All of these administrative data processing functions are necessary to manage the nationwide two-way wireless communications business. Mtel's systems developed for Skytel™ will be enhanced to support the unique needs of the NWN services.

1.1. Billing Module

The NOC will record information on all activity in the NWN system, including message input, message transmission and use of other functions like message recall. The control computer will write to disk detailed transaction records that include the following information:

- PIN number
- NWN ID code
- Transaction type
- Date
- Time of day
- NWN equipment type
- Elapsed connect time
- Length of message in characters
- Input port

By capturing this information, the system provides great flexibility in billing: usage sensitive billing, peak period pricing, connect-tone-based billing, and similar options.

All transaction records will be recorded on a disk in the NOC CPU, and then backed up to tape at selected intervals. The frequency of the tape backup process will be dictated by the volume of traffic flowing through the system. These tape records of activity can also be used for ad hoc MIS reporting on usage patterns, peak period analysis, and other aspects of system operations.

On an ongoing basis, customer "moves, adds and changes" will be keyed into the billing computer via the order entry module. On a monthly basis, the billing cycle will be run and all stored usage records will be "rated" according to the company rate tables defined in the billing system. Billing will be based on service requirements, user group billing plans, billing requirements and usage of the service. The rate tables can be modified easily to allow greater flexibility in marketing and sales programs.

1.2 Accounts Receivables Module

The quoted charging system will include a special cash posting screen and functionality for aging customer balances. Upon entering the account number, the account name and address will be given immediately for verification purposes. The software will include built-in daily and monthly reports that can be used for cash balancing, account history analysis, tax reporting and other important administrative purposes.

1.3 Collections Module

The collection module will include a complete "Customer Treatment" system for handling delinquency notices and collections activity. This module will be interfaced with the receivables module to provide real time updates of accounts.

Accounts may be coded according to credit records to allow selective delinquency treatment for different types of accounts. For example, "slow pay" corporate accounts can avoid getting payment reminder letters for small outstanding balances. Conversely, small "low credit" accounts can be turned off immediately at the first sign of a payment problem, to minimize bad debt.

On-line screens will be used by collections personnel to keep records of valuable customer information which may influence the treatment process.

1.4 Inventory Tracking Module

One of the single biggest investments over time for an NWN service company will be the imbedded base of subscriber equipment used by customers in equipment rental and lease-purchase programs.

Built-in reports on equipment utilization, monthly sales volume, equipment in and equipment out, total equipment inventory, etc. can be produced on a daily or monthly basis. These standard reports are valuable for procurement purposes or other business analysis. Also, any unidentified equipment can be traced back to its correct owner immediately.

1.5 Configuration Management and Order Entry Module

This module will allow the system administrator to enter work orders for the system. This will define for a subscriber what class of service they are requesting and what billing plan will be used to bill them for the service. This also will allow addition, deletion and modification of a subscribers service. Service dates and status will be monitored here. This module will link with the billing and inventory system.

1.6 Fraud Prevention and Detection

This module will allow the system administrator to control database and service assignments for subscribers. Both password protection control and audit programs will be provided to ensure database integrity and prevent fraudulent use of the system. Effective administrative procedures will be defined and implemented to prevent and detect fraud. Portable unit identification and/or serial numbers will be encrypted for radio transmission. The availability of all records for all customers in a centrally managed system will ensure that unauthorized units are not provided service in any location in the entire network.

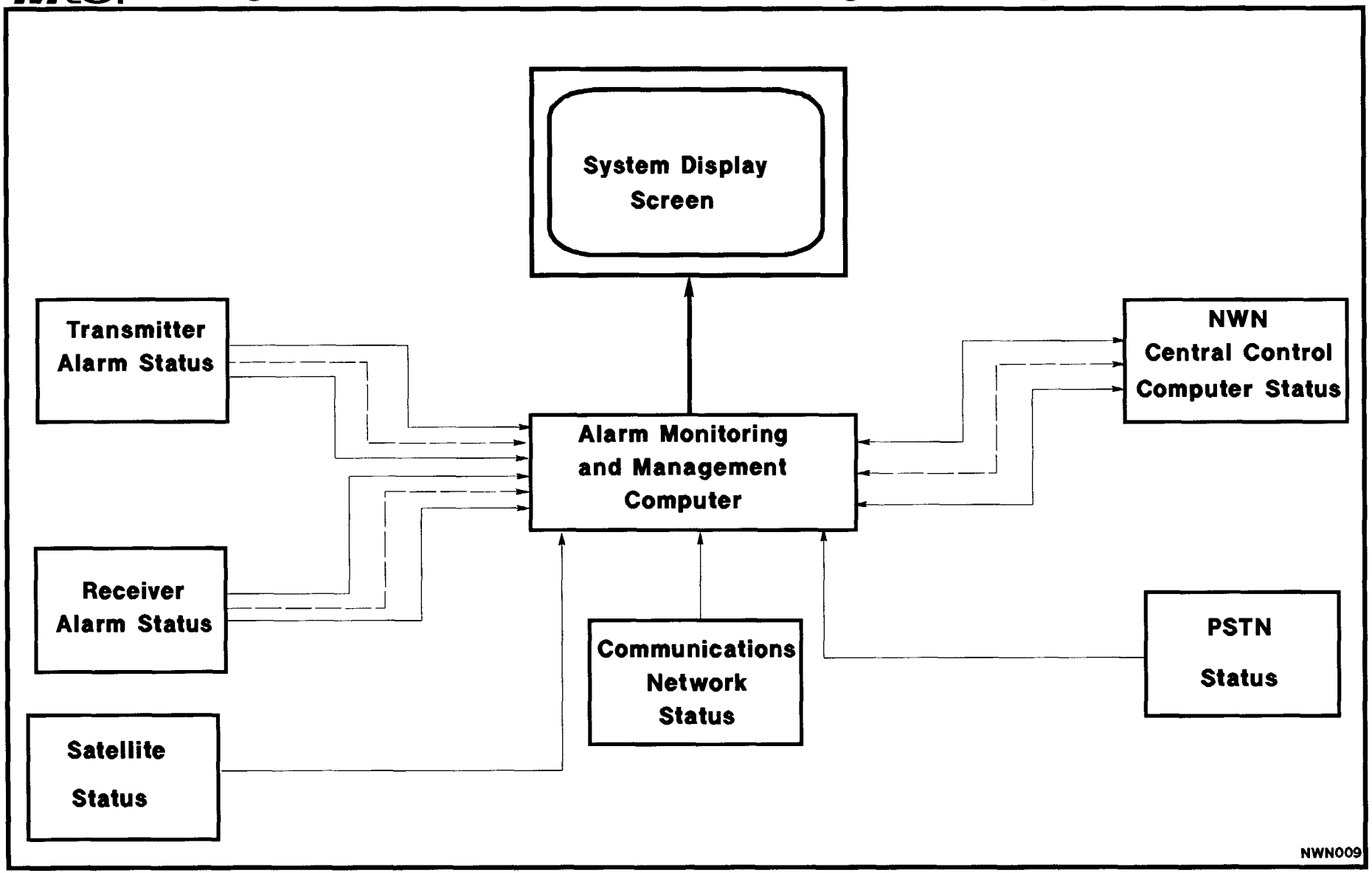
A2 Network Management

The sophistication and complexity of the NWN environment necessitates the creation, design and deployment of a network management system capable of monitoring the nationwide facilities to ensure system integrity and efficiency.

Such a system, in a block diagram form, is shown in Figure 12. Salient characteristics of this system include the total oversight of the NWN operations in terms of monitoring all its vital components, whether they are communication lines or transmitter status information.

The network management computer will receive "real time" information from its major components relating to the operational status of the system, as well as information relating to

Figure 12: NWN Network Management System



the distribution of the system resources, so that a more efficient use of the spectrum may be accomplished if the system software detects any anomaly.

One of the major advantages of using an automated network management system is its capability of optimizing load performance and ensuring that the system uses its resources efficiently. Monitored quantities will relate to:

- Operational Status of the NOC and Its Associated Systems
- Back-up System Status
- Integrity of Communication Links
- Traffic Loading/Patterns and Regional Distribution
- Operational Status of Transmitters and Receivers

Operational Status of the NOC and Its Associated Systems. The proposed system will monitor the functions of the RPSC and the NOC and will provide real time information relative to various major components of the system as follows:

- RPSC

  -- Information relative to traffic patterns of each RPSC
  -- Security management
  -- Transmitter alarm information
  -- Closed loop tests - to ensure operational status
  -- Database and archival setups for statistical studies
  -- Communication line status
  -- Escalation procedures in case of problems

If RSCs are employed, the operational status of these will also be monitored.

- NOC

  -- Communication line status (includes PSTN, PSN and Satellite)
  -- Computer system diagnostics
  -- Redundancy consideration
  -- Overall network security
  -- Monitoring external network resources (interface to other networks or service providers)

Backup System Status. One of the important aspects of the "nationwide" status of the system is in centralization. This provides an efficient way of managing the network resources. In such a system, redundancy can be easily accomplished since one has to backup

only one nationwide system, thus ensuring a better distribution of the available resources and a more efficient monitoring of the total system.

Quantities that will be monitored include:

- System traffic pattern and loading
- Communication links between redundant systems
- Load transfer capabilities
- System alarms

Integrity of Communication Links. Perhaps the most vital component of the NOC is its capability to interconnect with the RPSC, the PSTN, the PSN and the various external networks.

The communication links have redundancies and are monitored to ensure that all vital links are available at all times, thus ensuring maximum spectrum efficiency from the communication links point of view.

In case of a fault, the backup system will ensure uninterrupted service, with diagnostic information sent to the network management system.

Traffic Loading/Patterns and Regional Distribution. Another important network management consideration, particularly important in an NWN environment, is the real time monitoring of load traffic patterns.

The NWN will provide for adaptive registration based on a user's traffic pattern. It is extremely important that these patterns be monitored so that expert software systems and techniques may be applied to improve the efficiency of the system, and consequently make better use of the available spectrum.

Information received will be displayed on a large situation map that will show, at any one time, the "real-time" picture of the nationwide network. Monitored information, such as traffic patterns, alarm conditions, system diagnostics and operational status will be displayed in a manner that makes the system functional and provides the instantaneous recognition of the system performance as a whole with the added capability of recognizing and correcting weak points in the system.

Operators manning the system will have access to this information and interactively they may alter various patterns of operation, depending on observed traffic patterns or conditions that might decrease the system's efficiency. Knowledge of alarm conditions and their subsequent servicing will enhance the reliability of the system.

One of the key prerequisites in the design of such a system is centralization. In a nationwide system with a centralized Network Operation Center (NOC) such centralization is guaranteed.

Operational Status of Transmitters and Receivers. The capability of the proposed system to provide for adaptive registration of subscriber portable units, transparent to the user, is greatly enhanced by the vigilance of the network management system.

Thus, critical system components such as availability of return channel links, user interface systems, satellite communications channels and, in general, various components and parameters vital to the system's operation, will be monitored and critically evaluated in a "real time" environment.

Perhaps, the most important function of the receiver/transmitter monitoring scheme will be the "closed-loop test", during which each transmitter, in its own time slot, will broadcast a message to be received and reported back by each receiver. Thus, absence of reporting will disclose the operational status of the receiver/transmitter group.

Network Management Summary. Mtel, not only has experience in designing such a network management system as the one described above, but it has actually implemented one in our present nationwide paging system.

In support of Skytel™, most of the intricate software has been written by Mtel, and the hardware to implement the alarm conditions has been placed in strategic locations around the country.

Mtel's deployed system allows for the total monitoring and displaying of system wide alarm conditions, remote notification, elaborate security systems, and extensive database structures for achieving and analyzing accumulated alarm data.

The monitored information is displayed on two systems simultaneously (one in Jackson, MS and the other in Washington, D.C.), for redundancy purposes, in a "war-room" type environment with real-time interactive capabilities. Large maps of the U.S.A., with street level detail capability, allows for the exact display of the alarm condition.

Even though the existing system has been designed to monitor and control presently needed parameters and systems that are different than those required for the NWN, the major software components and structure are functionally equivalent.

Most importantly, Mtel's proposed network management system incorporates the innovation of being the first to apply on-line network management capabilities to a nationwide wireless network.

A3 System Maintenance

Performance Monitoring. The NOC will have the capability to monitor and administer both the central site and remote sites. Active displays of activities on various elements of the system will be provided. See Figure 12. System performance monitoring will generate an alarm when the threshold is reached on any element. Performance reports will also be stored for trend analysis and future capacity planning.

Performance Management. The NWN system performance will be managed for dynamic load balancing and long term capacity planning. The system manager will have built-in tools to support dynamic resource allocations to ensure proper throughput and turn around time for messages.

Diagnostics. An on-line diagnostic capability using an expert system will allow the system operator to troubleshoot and resolve problems promptly. The built-in expert system will reduce training time and make it easy to maintain such a complex system.

Network Reconfiguration. The NWN system manager will be able to reconfigure the system anytime to minimize downtime and increase system availability. A single point of failure in the system will be minimized and all single points of failure will be monitored. The system will be reconfigured when a failure is detected.

Maintenance. Preventive periodic maintenance will be carried out to reduce the probability of a failure. Both hardware and software will be on a seven (7) days a week, twenty-four (24) hours a day maintenance service contract. Mtel will also supplement this capability by using its own field technical personnel. The NOC will be staffed continuously.

A4 Security

As NWN services will be used for two-way information exchange, protection of computer and communication systems to offer a high level of security will be very important. All areas of security will be addressed.

- Physical
- Personnel
- Regulatory
- Hardware
- Software
- Network

Physical Security. All NOC and RPSC sites will have building and access security to ensure protection against unauthorized access to system computers. Buildings will provide proper computer room environment protection. Only authorized personnel with proper identification and electronic security badges will be able to access the system.

Personnel Security. Careful background checks for personnel and formal termination procedures will be in place to minimize personnel related threats to the network. Personnel procedures and practices will be implemented to limit access to the system based on a need to know basis. Supervisory monitoring and checks and balances will be part of security procedures to protect against personnel related security issues.

Regulatory Security. Computer and communications security laws in areas of privacy and sensitive information protection will be fully supported to ensure proper compliance with legal requirements.

Hardware Security. Protection of all hardware equipment against many possible security violations against hardware is very critical. Not only physical access to the hardware will be controlled but, also reliability and redundancy of the hardware environment will be considered to protect against hardware failures. Electronic identifiers will be used to ensure access security.

Software Security. Software threats in terms of virus, accidental destruction of data and destruction of programs will be addressed. Good development methodology and configuration control will not only improve the quality of the software, but will go a long way towards enhancing resistance to adversary attacks. Various audits will also be put in place for ongoing protection. Password access with privilege control will be implemented. Database security redundancy and integrity checking will be part of the system.

Network Security. Networks provide access to users of the system and carry information to destinations for delivery. The physical span of the network presents unique security issues. While password protection will be provided on the user access side, hackers pose a threat to dial-up access. For sensitive applications, dial-up port protection devices will be implemented. Data being transmitted over the air to the NWN portable terminal will have the capability to be encrypted and will also carry an encrypted hardware address for the destination device to protect against an unauthorized tap into the information.

A5 Reliability

For a nationwide two-way messaging service, reliability is extremely important. To increase the reliability of the entire system, fault tolerance, detection and isolation is implemented at every level in the system. This section will provide an overview of the measures planned by Mtel to ensure high reliability.